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The PPQ Weed Risk Assessment

Overview

Presented at
 National Plant Board Meeting
 Mystic, Connecticut
 July 23-26, 2012

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Who am I?

- Special Projects Coordinator for the PERAL Weed Team

Plant Protection and Quarantine
 Center for Plant Health Science and Technology
 Plant Epidemiology and Risk Analysis Laboratory
 Raleigh, NC

- Risk analyst – Plant population biology



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Our Mission


- Prepare weed risk assessments (WRA) in response to concerns about weed risk from customers
- Provide technical and resource support to colleagues and customers on weed and invasive plant issues
- Support PPQ's mission of plant protection by proactively identifying and assessing noxious weeds and pest plants of concern

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What is Weed Risk Assessment?

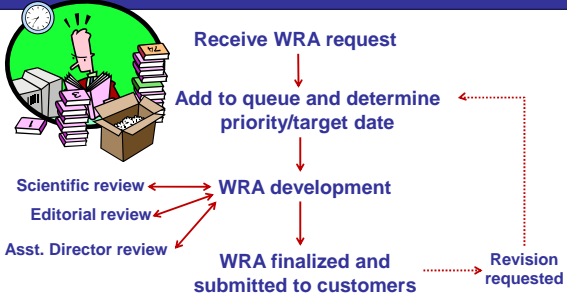
WRA: An evaluation of the probability of the introduction and spread of a plant, and of the potential consequences, helping us to make informed management decisions that will reduce the economic and ecological harm caused by weedy and invasive plants



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Our WRA process



Receive WRA request

Add to queue and determine priority/target date

WRA development

WRA finalized and submitted to customers


Revision requested

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Style of the assessment

- Mostly Yes/No questions; a few multiple choice
- Record uncertainty: negl, low, mod, high, max
- Evidence and supporting documents recorded for each



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Risk Elements in the WRA

- Establishment / Spread Potential (23)
- Impact Potential (18)
- Geographic Potential (3/36)
- Entry Potential (14)

Predictive model

Uncertainty Analysis

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The Predictive Model

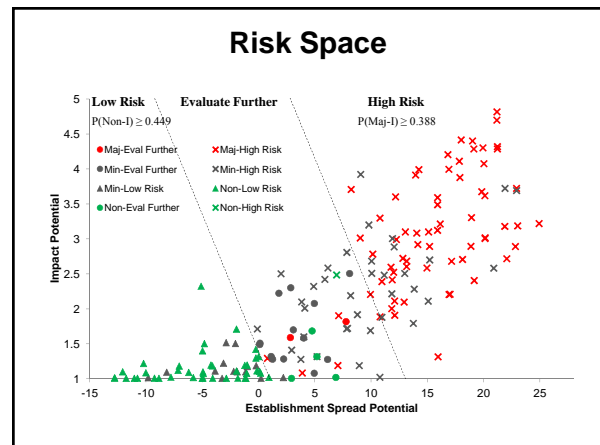
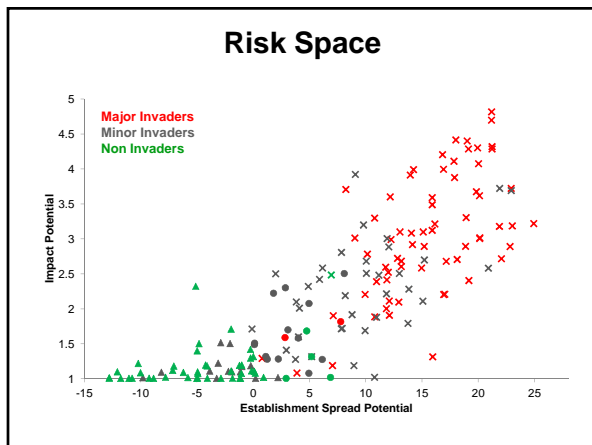
- Calculates Prob (invasiveness) using a logistic regression model

$$P(\text{Maj-I}) = \frac{1}{1 + e^{-(\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_n X_n)}}$$

$$P(\text{Min-I}) = \frac{1}{1 + e^{-(\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_n X_n)}}$$

$$P(\text{Non-I}) = 1 - \left(\frac{1}{1 + e^{-(\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_n X_n)}} \right)$$

- $P(\text{Non-I}) + P(\text{Min-I}) + P(\text{Maj-I}) = 1$
- Developed & validated with 204 U.S. species



Model Performance

(validation dataset)

Test	Accuracy		Error	
	Maj-Invaders (True +)	Non-Invaders (True -)	Non-Invaders (False +)	Maj-Invaders (False -)
US - PPQ WRA	0.941	0.971	0.000	0.000
US - Aus WRA	0.971	0.794	0.088	0.000
Mean (8 other AUS tests)	0.936	0.715	0.164	0.022

- Overall accuracy is higher than the Australian WRA
- Non-invader and major-invader performance similar

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Risk & Uncertainty

Uncertainty is a component of risk

A good PRA always documents uncertainty

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Documenting uncertainty in the PPQ WRA

Probability

- Negl → 0.1%
- Low → 1%
- Mod → 10%
- High → 25%
- Max → All answers equally likely

Uncertainty describes our confidence in our answers.
Expresses our belief that some other answer is correct.

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Evaluate the sensitivity of a species' risk scores to uncertainty

What would the final risk score be if we chose a different set of answers?

ES-8	Grass (y, n, or ?)	n	0	negl
ES-9	Nitrogen-fixing woody plant (y, n, or ?)	n	0	negl
ES-10	Produces viable seed or spores (y, n, or ?)	y	1	negl
ES-11	Self-compatible or apomictic (y, n, or ?)	n	-1	high
ES-12	Requires specialist pollinators (y, n, or ?)	n	0	mod
ES-13	Minimum generative time (A) less than 1 (multiple generations per year), (B) 1 year	?		max
ES-14	Prolific seed/spore production (see scoring)	y	1	negl
ES-15	Propagules likely to be dispersed	y	1	negl
ES-16	Propagules likely to disperse as a produce	y	2	mod

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Monte Carlo Simulation (@Risk)

- Randomly change answers based on the uncertainty level
- Calculate the new risk scores
- Determine the new result, and run secondary screening if necessary
- Repeat this 5000 times
- Plot and evaluate simulated risk scores

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Example – *Rumex sagittatus*

Benefits

- Dig deeper?
- Is result robust?
- Suggests possible decision for Evaluate Further

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Climate – Geographic Potential


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Climate

- Influences the success of colonizing species
- Climatic suitability in WRAs
 - Species adapted to climatic conditions receive higher risk scores
- Predictive WRA model does not include climatic suitability
 - The U.S. is very diverse
 - Climate suitability is evaluated separately using a *simple* climate matching tool

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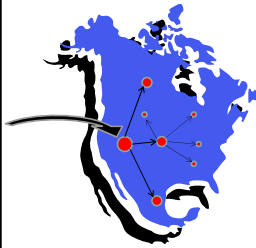
Geographic Potential



- Each WRA includes a predictive map
 - Joint the overlap of the 3 climatic variables
 - Cold hardness, Annual precipitation, Köppen-Geiger climate class
- Calculate & report the percentage of the U.S. suitable for establishment
- Report the climatic profile

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Entry Potential




- Entry – Movement of a pest into an area
- 14 questions (y/n, mult. choice)
 - Intentional
 - Unintentional
- Not necessary most of the time
- Useful for contaminants

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The Final Product

- **Word/PDF document**
 - 12-15 page summary of results from Excel file
 - Always submitted to customers
- **Excel file**
 - Kept separate, but available upon request



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The Final Product

- Background: Initiation, distribution, US status
- Narrative summary of risk elements
- Map of potential US distribution
- Results & conclusions
 - Risk score in relation to the 204 species
 - Graphical results of the uncertainty simulation
- Discussion
- Literature Cited
- Appendix: excerpt of the Excel assessment



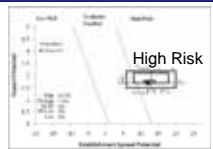
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Completed WRAs

Taxon	Conclusion	Taxon	Conclusion
Alpinia modesta	Low Risk	Berberis glaucocarpa	High Risk
Artemisia austriaca	High Risk	Luziola subintegra	High Risk
Artemisia japonica	Evaluate Further	Persicaria capitata	Evaluate Further
Praxelis clematidea	High Risk	Phyllanthus fluitans	High Risk
Rhamnus alaternus	High Risk	Rauvolfia vomitoria	High Risk
Limnobiium laevigatum	High Risk	Acalypha australis	Evaluate Further
Oplismenus hirtellus ssp. und.	High Risk	Althaea armeniaca	Low Risk
Nymphoides cristata	High Risk	Hakea sericea	High Risk
Mikania micrantha	High Risk	Hippophae rhamnoides	High Risk
Syzygium australe	High Risk	Solanum seaforthianum	High Risk
Vitex rotundifolia	High Risk	Achyranthes japonica	High Risk
Agrostis stolonifera	High Risk	Dipogon lignosus	High Risk
Poa pratensis	High Risk	Neptunia oleracea	High Risk
Falcaria vulgaris	High Risk	Oxalis exilis	High Risk
Nymphoides peltata	High Risk	Araujia sericifera	High Risk
Phyllostachys aurea	High Risk	Arundo donax	High Risk
Echinochloa pyramidalis	High Risk	Nymphoides indica	High Risk
Pilea hyalina	Evaluate Further	Toona sinensis	High Risk

Completed=36; Development=5; Queue=47

Hippophae rhamnoides (Elaeagnaceae)

- Cultivated in the U.S., naturalized in 2 WY counties
- Become very invasive in Canadian prairies
- Forms dense thickets, N-fixer, alters natural habitats

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Opportunities & Challenges in WRA

- Weeds won't wait
- Lots of plants out there
 - Plants that are here
 - Plants that are coming
- Limited Resources



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Working Together

- What we can do for you
 - Do WRAs for some of your weeds
 - Inform you when we have completed WRAs
 - Train & mentor you to do your own WRAs
 - Provide literature information to support your efforts
- What you can do for us
 - Tell us about new and emerging weed threats
 - Identify weeds not yet in the U.S. that could be problematic
 - Collaborate on WRA projects (evidence, experts, review)



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For more information or to submit requests for WRA

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Our Vision

To be globally recognized as a credible authority in weed risk assessment



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The PPQ Weed Risk Assessment



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Our Customers




- APHIS headquarters (e.g., Noxious Weed Program, Plants for Planting staff)
- Other Federal agencies (e.g., Forest Service, Fish & Wildlife Service, National Park Service)
- State and local governments
- Non-governmental organizations
- Any individual, group, or other "legal entity"

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Our history with WRA

- **2005:** PERAL started doing WRA using a narrative process
- **2008:** Formed a team
 - began redesigning our WRA procedure
- **2010:**
 - Completed development
 - Assessing weeds and invasive plants
- **2011:** Published a paper
- **Sept 2011:** First WRA-101 training

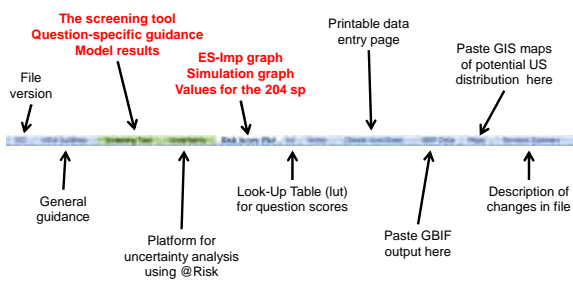


Our history with WRA (cont.)

- **January 2012-present:**
 - Doing WRAs
 - Getting organized
 - Identifying team mission/vision/goals
 - Developing project management process
 - Launching team SharePoint site
- **May 2012:** ISO certification
- **June 2012:** second WRA 101 training



Platform: Microsoft Excel Workbook



Labels in the screenshot include: File version, The screening tool, Question-specific guidance, Model results, ES-imp graph, Simulation graph, Values for the 204 sp, Printable data entry page, Paste GIS maps of potential US distribution here, Description of changes in file, Paste GBIF output here, Look-Up Table (lut) for question scores, Platform for uncertainty analysis using @Risk, and General guidance.

Weed Risk Assessment

Pre-border Screening Tools

- Goal: Assess invasive and weedy potential (prediction)
- Traits: Behavior elsewhere, congeners, climatic compatibility, inherent species traits (invasiveness & impact)

Introduction → Escape → Naturalization → Spread → Impact

Post-border Charac. & Prioritization Tools

- Goal: Characterize current invasions to help prioritization
- Traits: Impacts, potential distribution, and feasibility of control

Sample Questions

- **Establishment/Spread**
 - Climbing or smothering growth habit?
 - Self-compatible or apomictic?
 - Propagules bird dispersed?
- **Impact**
 - Change community composition?
 - Change or limits recreational use of an area?
 - Reduce crop/product yield?

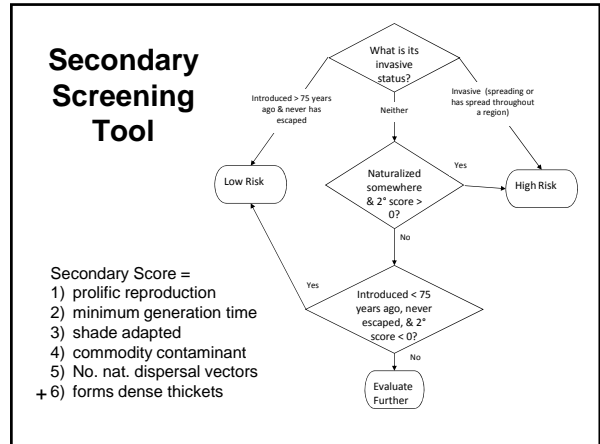
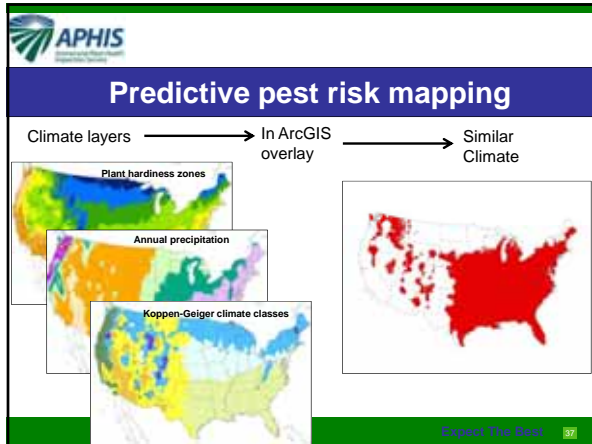
Summarizing uncertainty for each risk element

0 ←————→ 1
Uncertainty Index

- **Uncertainty level**
 - (negl, low, mod, high, max)
- **Question weighting**
 - (e.g., ES: 0 to 10 points)

Species	E/S	Impact
A	0.18	0.20
B	0.20	0.03
C	0.17	0.10
D	0.22	0.36

From our model validation (N=204) mean uncertainty = 0.17



Predictive Model has been Published

Development and validation of a weed screening tool for the United States
 Anthony L. Koop, Larry Fowler, Leslie P. Newton & Barney P. Caton

Biological Invasions

Springer

Geographic Potential

Cold Hardiness Zones	Köppen-Geiger Climate Classes	10-inch Precip Bands
Zone 1 (below -50F or below -45.6C)	Tropical rainforest	0-10 inches (0-25 cm)
Zone 2 (-50 to -40F, or -45.6 to -40.0C)	Tropical savanna	10-20 inches (25-51 cm)
Zone 3 (-40 to -30F, or -40.0 to -34.4C)	Steppe	20-30 inches (51-76 cm)
Zone 4 (-30 to -20F, or -34.4 to -28.9C)	Desert	30-40 inches (76-102 cm)
Zone 5 (-20 to -10F, or -28.9 to -23.3C)	Mediterranean	40-50 inches (102-127 cm)
Zone 6 (-10F to 0F, or -23.3 to -17.8C)	Humid subtropical	50-60 inches (127-152 cm)
Zone 7 (0 to 10F, or -17.8 to -12.2C)	Marine west coast	60-70 inches (152-178 cm)
Zone 8 (10 to 20F, or -12.2 to -6.7C)	Humid continental warm summers	70-80 inches (178-203 cm)
Zone 9 (20 to 30F, or -6.7 to -1.1C)	Humid continental cool summers	80-90 inches (203-229 cm)
Zone 10 (30 to 40F, or -1.1 to 4.4C)	Subarctic	90-100 inches (229-254 cm)
Zone 11 (40 to 50F, or 4.4 to 10C)	Tundra	100+ inches (254+ cm)
Zone 12 (50 to 60F, or 10 to 15.6C)	Icecap	
Zone 13 (above 60F, or above 15.6C)		

Other Potential Risk Elements / Modules

- Feasibility of control
- Extent of current and potential range
- Extent of cultivation
- Biofuels
- GMOs & LMOs

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Species Information

Sidastris montana L. - Mountain ironwort
 Family: Lamiaceae

Initiation → At the 14th annual South Dakota Weed and Pest Conference (February 23, 2012), Ron Moschering (South Dakota Department of Agriculture) told Anthony Koop (USDA-APHIS-PPQ) that *Sidastris montana* is a plant of concern to the state. The PERAL Weed Team initiated this assessment in response to that concern.

Foreign distribution → This species is native to some of the countries bordering the Mediterranean Sea (Algeria, France, Greece, Italy, Morocco, Spain, Tunisia), other countries in Southeastern Europe (Azerbaijan, Bulgaria, Romania, the East: Yugoslavia), Middle Europe (Austria, the Czech Republic, Hungary), eastern Europe (Moldova, Russian Federation, Ukraine), and Middle Asia (Afghanistan, Armenia, Azerbaijan, Georgia, Iran, Lebanon, Pakistan, Syria, Turkey, Turkmenistan) (SDGPP, 2012). It is a casual alien in the United Kingdom, Iceland, Norway, and Sweden (Clemens and Foster, 1994; GBIF, 2012; Russell, 2012; Reynolds, 2002). It is also present in the Kashmir Valley of India (Kost, 1988), but it is unclear if it native to that region.

U.S. distribution and status → *Sidastris montana* is known to be established in five counties across four U.S. states: Arkansas, South Dakota, Nebraska, and Montana. It has been present in Fulton County Arkansas since at least 1966 (Lang, 1988), with no reports of spread since then. However, since its initial discovery in South Dakota in Black Hills National Park in the 1980s, it has appeared in Buffalo Gap National Grasslands and on lands protected by The Nature Conservancy in Cotuit Basin (Kovach, 2012); all three of these areas are in the same vicinity in Pennington County. It is also reported from Ft. Pierre National Grasslands in Lyman County, South Dakota, where it is naturalized but apparently not behaving as an invasive species (Kovach, 2012, 2013). It is present in northwestern Nebraska in Dawes County in Ogallala National Grassland (Kovach, 2012; Kovach, 2012). Finally, it was recently discovered in Montana (Kovach, 2012).

WRA area: Entire United States, including territories

1. Analysis Results:

Establishment/Spread Potential

Text summary → [Text summary of *Sideroxylon montanum* characteristics and spread potential]

Risk score → Risk score = 10

Impact Potential

Uncertainty index → Uncertainty index = 0.28

Sideroxylon montanum is an annual herb that has naturalized in the United States (Kartesz, 2012; Korman, 2012; Kováč, 2012). Because it has established in several natural areas in South Dakota and Nebraska (over U.S. distribution), this species has demonstrated a capacity to spread. Based on evidence from Europe, it appears to readily disperse as a grain contaminant (Dunn, 1993; Jelski and Dvorák, 2008; Reynolds, 2002), and one source manager suggests it may also disperse on field equipment (Korman, 2012). However, it is not entirely clear which natural dispersal vectors, if any, have contributed to its spread in the United States, particularly in the natural areas described previously. *Sideroxylon montanum* produces several thousand seeds per plant and does not require specialist pollinators (AgroAtlas, 2012; Perrano Oddo et al., 2004). Because it can self-pollinate (Pinske and Pahl, 2009), individual plants can found new populations. Because little is known about this species' biology, this risk element had greater than average uncertainty associated with it; several questions were answered as unknown.

We found almost no information about the kind or degree of impacts this species has. Most information only states that it is considered a weed of cultivated crops, particularly cereals such as wheat (AgroAtlas, 2012; Dunn, 1993; Hunt, 1993; Keller et al., 1933). Because one source states it is susceptible to herbicides (Hiscox et al., 2005) and another states how to control it (AgroAtlas, 2012), we can reasonably assume that its impacts are significant enough to warrant some level of control. One study reports that it occurs at densities of about 2.7 plants per square meter in spring-sown wheat in Turkey (Balut et al., 2010). This same study reports a yield loss in wheat due to weeds, including *S. montanum*, but does not specify how much is attributable to each species. The genus *Sideroxylon* has been shown to contain various flavonoids that exhibit antifedant, anti-inflammatory, and antimicrobial properties (Baillie et al., 2011; Bondi et al., 2000). Thus, it may be unpalatable (Kováč, 2012), which would lower the grazing value of rangelands. *Sideroxylon montanum* occurs in several national parks and grasslands in the badlands region of the United States. As these types of areas are set aside for the conservation of native species and landscapes, *S. montanum* can be considered a weed of natural areas. However, what impacts, if any, it is having in these areas is unknown. Overall, there was a high level of uncertainty associated with this risk element. Risk score = 2.2. Uncertainty index = 0.45.

1. Analysis Results

Geographic Potential

Text summary and U.S. map (Figure 1) → [Map of the United States showing the geographic potential for *Sideroxylon montanum* establishment]

Text summary (and risk score and uncertainty index, if applicable) → [Text summary of geographic potential]

Entry Potential → [Text summary of entry potential]

Based on these climatic variables, we estimate that about 10 percent of the United States is suitable for the establishment of *Sideroxylon montanum* (Fig. 1). This potential distribution is based on the species' known distribution elsewhere in the world and includes grain-contaminant locations and areas of occurrence locally from USDA, 2012. The map shown in Fig. 1 represents the geographic distribution of *Sideroxylon montanum* in the United States based on current geographic data, and the following larger climate change ranges. Given uncertainties about potential future climate change, the geographic distribution of *Sideroxylon montanum* may change in the future.

We were estimated in Fig. 1 that a conservative estimate of the United States suitable for the establishment of *Sideroxylon montanum* is about 10 percent of the United States. This potential distribution is based on the species' known distribution elsewhere in the world and includes grain-contaminant locations and areas of occurrence locally from USDA, 2012. The map shown in Fig. 1 represents the geographic distribution of *Sideroxylon montanum* in the United States based on current geographic data, and the following larger climate change ranges. Given uncertainties about potential future climate change, the geographic distribution of *Sideroxylon montanum* may change in the future.

Figure 1. U.S. map showing suitable areas for the establishment of *Sideroxylon montanum*. The map shows the United States, with the area suitable for the establishment of *Sideroxylon montanum* shaded in red.

Sideroxylon montanum is already established in the United States (Kartesz, 2012; Korman, 2012; Kováč, 2012). The following text is a summary of the species' biology.

2. Results and Conclusion

Model probabilities for Major, Minor, and Non-Invasive

Risk score (High Risk, Evaluate Further, or Low Risk)

Secondary Screening result (if applicable)

Model Probabilities: P(Major Invader) = 18.1%, P(Minor Invader) = 16.0%, P(Non-Invader) = 65.9%

Risk Result = High Risk
Secondary Screening = Not Applicable

Figure 2. Risk score (■) relative to species used to develop the model

Figure 3. Shows effect of uncertainty on the risk score (■)

Figure 2 shows a scatter plot of risk scores for various species. The x-axis is 'Establishment/Spread Potential' and the y-axis is 'Risk Score'. Data points are colored by risk level: High Risk (red), Evaluate Further (orange), and Low Risk (green). *Sideroxylon montanum* is highlighted with a black square.

Figure 3 shows a similar scatter plot but with shaded regions representing uncertainty in the risk scores for each species.

3. Discussion

Summary and discussion of overall results of assessment

Includes effect of uncertainty on final conclusion

May include additional information that may be useful for risk managers

4. Literature Cited

The overall risk assessment for *Sideroxylon montanum* is High Risk, as it is listed on the Federal Register as a species of concern. The species is currently established in the United States, and its geographic distribution is expanding. The species is a grain contaminant and is a weed of cultivated crops. The species is also a weed of natural areas and is a threat to native species and landscapes. The species is also a weed of urban areas and is a threat to human health. The species is also a weed of agricultural areas and is a threat to crop production. The species is also a weed of industrial areas and is a threat to infrastructure. The species is also a weed of recreational areas and is a threat to the environment. The species is also a weed of cultural areas and is a threat to heritage. The species is also a weed of scientific areas and is a threat to research. The species is also a weed of historical areas and is a threat to history. The species is also a weed of religious areas and is a threat to faith. The species is also a weed of political areas and is a threat to governance. The species is also a weed of social areas and is a threat to community. The species is also a weed of economic areas and is a threat to prosperity. The species is also a weed of environmental areas and is a threat to sustainability. The species is also a weed of cultural areas and is a threat to heritage. The species is also a weed of scientific areas and is a threat to research. The species is also a weed of historical areas and is a threat to history. The species is also a weed of religious areas and is a threat to faith. The species is also a weed of political areas and is a threat to governance. The species is also a weed of social areas and is a threat to community. The species is also a weed of economic areas and is a threat to prosperity. The species is also a weed of environmental areas and is a threat to sustainability.

Appendix A

Excerpt of the Excel risk assessment

For each question, provides:

- answer and uncertainty rating
- risk score
- evidence

Appendix A provides a detailed Excel spreadsheet for the risk assessment of *Sideroxylon montanum*. The spreadsheet includes a table of questions, answers, uncertainty ratings, risk scores, and evidence. The table is organized into columns for each of these categories. The questions cover various aspects of the species' biology, ecology, and impact. The answers provide detailed information for each question. The uncertainty ratings indicate the level of confidence in the answers. The risk scores are calculated based on the answers and uncertainty ratings. The evidence provides references for each question.